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ON THE EFFECTS OF LIGHTNING ON CERTAIN TREE-SPECIES.

The traces left on trees by the electric discharge from clouds had never till recent years formed the object of precise observations; and the scanty data acquired could hardly warrant a scientific opinion as to the mode of action of this discharge. There were obvious reasons for the existence of this gap in the domain of meteorology; among others, the fact might be mentioned, that such data as were required were not liable to be furnished by a meteorological station, and it is from the record of observatories, almost exclusively, that precise meteorological observations are obtained. The subject under notice has some time occupied the attention of the Swiss observer, M. Daniel Colladon, and the memoir upon it which he has communicated to the Genevan Society of Physics and Natural History, is a comprehensive repertory of facts which are both of theoretical and practical interest. M. Colladon has carefully investigated and described the effects of electricity on different species of trees. In this connection, it is well known that the poplar presents certain peculiarities; and the results of his observations of this species may here be briefly considered.

All the upper part of the trees struck remained perfectly sound; there was no dry branch to be seen. The height above the ground at which commence the wounds or visible traces does not, in large poplars, exceed the third of the tree's height. These wounds commence immediately below the junction of the strong branches with the principal trunk. In general they do not reach to the ground; they are mostly limited to 0·30, 0·40, or 0·50 metres above the ground. In the majority of cases the wounds are situated on the parts of the trunk turned towards the south, the east, or the west.

Horace observed that it was the loftiest mountains that were struck by lightning—*Feriuntque summos fulmina montes;* and he might have made a similar remark about certain trees. It is always the tallest poplar that is struck. In certain cases, however, the storm will pass over trees of another species,—oaks, acacias, elms, chestnuts, lime-trees, &c.,—without striking them, and will explode on poplars which are even less in height.

Having carefully examined hundreds of specimens of fragments of wood or bark torn from wounds made by lightning in poplars that were in healthy condition, and having also, in each case, examined the borders of the fissures and wounds, both of wood and bark, M. Colladon never met with any traces of real carbonisation. It is an important condition that the tree be living and healthy. The edges of the fissures and wounds, of bark and wood, nearly always present fibres torn asunder and reduced to the state of fringes or thick tow.

The cases in which several poplars have been injured by a single discharge of lightning are rare. One such case was brought before the author's notice at Wildegg, in the canton of Argovie, by M. Laué. This gentleman showed him three beautiful poplars which he had had cut down because their trunks had been damaged, a few days before, by one and the same stroke. A fourth tree, a lime, which was quite near, had also a wound on its bark—commencing at two-thirds of its height, and descending nearly to the ground. This lime tree had visibly suffered—its leaves were blighted—and M. Laué was about to cut it down. These four trees were on the summit of a high and steep slope, at the base of which flowed a river. They were in a straight line, and about three metres distant from each other.

The utility of poplars planted near a house, as lightning-conductors, deserves more consideration, perhaps, than it has yet received. Their growth is rapid; they rise to a height of thirty to thirty-five metres; and their upper parts, especially, are excellent conductors of the electric fluid. Moreover, they occupy but little space, and have no injurious effects on houses.

There are, however, cases in which a poplar situated near a house may become more dangerous than useful. Such is the following, recorded by M. Colladon:—Pastor Theremin had a farm on the dry and elevated plateau of Onex, near the village of Lancy. Close to the house, on the east side, rose a lofty poplar; on the west side there was a pond. On the 13th July, 1864, lightning struck the poplars, and, to reach the pond, it passed from the poplar to the edge of the roof, whence, probably following the beams fitted with iron pieces, it traversed a loft filled with straw, and the farm-steading was set on fire. In this case it would have been desirable either to place the pond on the same side of the house with the poplar, or to have connected the lower part of the poplar with the pond by means of a strong rod of metal; thus an excellent lightning-conductor would have been obtained.

In conclusion, the proprietors of houses who have not provided them with special lightning-conductors, and who consider these houses to be

protected by neighbouring tall trees, would do well to connect with the trunks of those trees rods of iron, continued through the ground to a reservoir, or fountain, or well, or deeply inserted in a soil that is constantly moist.

ON THE CONSTITUTION AND MAGNETISM OF STEEL.

THE constitution of steel bars may differ on two accounts—their chemical composition, and the mechanical treatment to which they have been subjected. Chemically, steels vary according to the quantity of carbon they contain; physically, according to the degree of hardness given them, by heating and quick extinction of the heat in cold water, and by the after process of annealing.

In both directions vary also the magnetic properties of steel; and numerous researches on its magnetism, as thus determined, have been published. In a recent paper to the Göttingen Society of Sciences, M. Fromme studies the question of the influence of hardening on the remanent magnetism of steel. This has often been discussed, without, however, decisive results. The observers have taken opposite sides, some attributing to hardened steel, others to annealed steel, the greater power of retaining magnetism. Thus, Müller, Plücker, and Wiedemann took the former view; Hansteen and Lamont, the latter; while Coulomb, after numerous observations, considered the question as still open.

After some researches on the magnetism of soft steel bars, M. Fromme was about to proceed to an investigation of the point, when a paper of M. Ruths (an inaugural dissertation in 1874) came into his hands, and it seemed to him of a decisive character.

M. Ruths found that the *dimensions* of the bars must be taken into account. Cylindrical bars in which the relation of the length to the thickness is greater than 30, retain in the hardened state less magnetism than when annealed in the yellow, and in the latter less than when annealed in the blue. In like manner behave also thicker bars, so long as the inducting forces are small; with greater forces the case is different; so that, in general, bars in which the ratio of the length to the thickness is less than 30, have the greater power of retention in the hardened state. "Thus with small magnetising forces, an annealed bar always takes more magnetism than a hardened one, otherwise similar. But, since the magnetism in the hardened bars increases in greater proportion than in the annealed ones, a value of the magnetising force is reached, at which the magnetism of the hardened bar reaches that of the annealed, and thereafter exceeds it. This indifferent magnetising force is smaller, the thicker the bar in comparison to its length. Its value increases with increasing length and decreasing thickness, and, at a certain proportion of these two magnitudes, becomes infinitely great." It is an important confirmation of these results that the contradictions of all previous observers are fully explained, when regard is had to the dimensions of the bars. M. Fromme, however, tested the matter experimentally.

Eight steel bars of 100 mm. length, of which four (I) were 7 mm. thick, the other four (II) 2 mm. thick, were hardened in the same manner. The temperatures to which they were heated varied between 947° and 1467°. Of the bars, I_1 and II_1 were left hard, I_2 and II_2 annealed to the oxidation colour yellow, I_4 and II_4 to blue, I_3 and II_3 to disappearance of all oxidation colours. The bars were magnetised to saturation by touch, and their magnetic moment determined. The following values were obtained, and they are compared with those got from natural bars, with the same kind of magnetisation:—

		Natural.			*Natural.*
I.	1. 1982	660	II.	1. 413	232
	2. 1508	630		2. 448	234
	4. 1118	624		4. 440	263
	3. 1051	609		3. 475	227

These numbers fully confirm M. Ruths' result, at least for strong magnetising forces. It further appears, that with thin bars it makes very little difference; with thick bars a considerable difference, whether one magnetises the steel hardened or annealed. For very small magnetising forces, on the other hand, which in practice do not come into consideration, the magnetisms of the thinner bars present, according to Ruths, greater differences. It will be perceived, however, how very disadvantageous it is to use natural bars for magnets, for in every case the power of retention increases through the hardening.

M. Fromme accords to M. Ruths, then, the priority in deciding this question. Quite recently M. Gaugain has communicated to the Paris Academy results which fully agree with those of Ruths.

As to the possible cause of these phenomena, M. Fromme offers the following opinion: "Determining the specific gravity of steel bars of natural, hardened, and annealed steel which I wished to use in further researches, I found the difference of specific gravity of a natural and a hardened bar considerably greater than I had anticipated, or than I found in Lamont's Handbook, and in a table of specific gravities. I therefore, myself made some experiments on bars of different dimensions.

"In hardening of a steel bar, there is an increase of volume, and so a decrease of the specific gravity; the coefficient of dilatation lies between 1·010 and 1·013. In annealing to the oxidation colour yellow there is a contraction; the coefficient of which is about 0·9945; that is, the specific gravity has again approximated to that of the natural state to the extent of a half. With further annealing to blue, the bar contracts further; coefficient of contraction about 0·997. It is only after heating till the disappearance of all oxidation colours (grey) that the bar reaches the specific gravity which it had before hardening.

"Hence we infer that with sudden extinction of a glowing steel bar there forms a very hard superficial layer, which cooling more quickly than the interior, restrains the latter in its contraction. Thus the interior is in a tense state, caused by the outer solid crust; the latter is very hard, the former soft. The consequence is the enlargement of volume observed.

"We may regard a hardened steel bar as consisting of concentric layers, whose hardness quickly diminishes from without inwards, ultimately enclosing a soft heart. In slow heating to gradually higher temperatures, the molecules again arrange themselves regularly, and it might be supposed that with the annealing temperature at which the specific gravity before hardening is reached again, the molecular state of bar is also the same again. The magnetic behaviour, however, contradicts this. The much greater magnetism of the grey bars compared with that of the red indicates a crystalline arrangement of the molecules different from that of the natural state.

"Now I have found that steel bars of different thickness, otherwise alike, hardened in the same manner, show a different decrease of the specific gravity, the thin ones a greater, the thick ones a less. It may probably be inferred, that hardened and annealed steel bars of different thickness show a different magnetic behaviour, because the proportion of the outer harder part to the inner softer part is different.

"I conceive the process of magnetisation of a hardened steel bar thus: In each individual layer the separating force excites a remanent magnetism, the amount of which continuously decreases from without inwards. But from the remanent magnetism of each layer is subtracted the opposite induced magnetism which is excited by the remanent of all the other layers, and the amount of which increases from without inwards. The proportion of these two parts to each other is determinant for the amount of the resulting magnetism coming outwards; it further determines whether a bar takes more magnetism in the hard or in the annealed state. Thus the greater or less value of the remanent magnetism of steel bars finds its explanation, when we consider not only the laws of the remanent, but also those of the temporary induced magnetism.

"Without proceeding to further establishment of this hypothesis, which I wish to test by further experiments, I will only refer to a result of Holtz's, which, along with another of Jamin's, may serve as verification. Holtz, having dissolved in hydrochloric acid magnetised bars, both hardened and annealed, found that in the removal of the outer layers the magnetic moment of unit weight increased more and more, but in greater proportion in the hardened than in the annealed bars.

"The explanation is easily furnished, according to my hypothesis, as follows:—In the removal of the outer hard (and, of course, most strongly magnetic) layers, a considerable portion of the magnetism is also removed; and one might therefore expect rather a decrease of the magnetic moment of unit weight. That this does not occur is proof that at the same time opposing forces are removed—namely, the opposite induced magnetism. Its influence was so great, that even the moment of the unit weight increases; and the increase must be less in annealed bars, because in them the inequalities of the individual layers are in part removed by annealing."

A Chinaman in California cut down telegraph-poles and used them for firewood; he thought they grew there!

ON THE CHARGES TAKEN BY DIFFERENT LENGTHS OF CABLE.

BY F. C. WEBB AND H. R. KEMPE.

LET A B be a cable whose further end is to earth, and whose nearer end is charged by a battery whose second pole is to earth.

If V represent the potential of the battery when insulated, v will be the potential of the charge at B.

Now R_l and ρ being the resistance of the conductor of the cable and of the battery respectively—

$$V : v :: R_l + \rho : R_l$$

therefore

$$v = \frac{V R_l}{R_l + \rho}$$

The charge in the cable is represented by the area of the triangle A B D, which is equal to $\frac{v R_l}{2}$, or if we call this charge Q_l then

$$Q_l = \frac{v R_l}{2} = \frac{V R_l^2}{2 (R_l + \rho)}$$

If now we have a second cable whose conductor resistance is R_2, the charge Q_2 which it would take would be

$$Q_2 = \frac{V R_2^2}{2 (R_2 + \rho)}$$

then

$$Q_l : Q_2 :: \frac{V R_l^2}{2 (R + \rho)} : \frac{V R_2^2}{2 (R_2 + \rho)}$$

or

$$Q_l : Q_2 :: \frac{R_l^2}{R_l + \rho} : \frac{R_2^2}{R_2 + \rho}$$

Now, if the resistance of the cable be large compared with the resistance of the battery employed to charge it, in the equations, ρ may be neglected, in which case—

$$Q_l : Q_2 :: \frac{R_l^2}{R_l} : \frac{R_2^2}{R_2}$$

or

$$Q_l : Q_2 :: R_l : R_2$$

showing that

"*When a cable whose further end is to earth is charged by a battery whose resistance is small compared with the resistance of the conductor of the cable, the charge it will take will be* directly *proportional to its length.*"

Geometrically this may be proved very simply.

In the fig. let A B and G B represent the conductor resistances of two cables, and B C the resistance of a battery employed to charge them.

Now the smaller B C is compared with A B and G B, the nearer will D B and F B approach equality.

If we regard them as equal, then the areas of the two triangles representing the charges in the two cables will be $\frac{DB.\ AB}{2}$ and $\frac{DB.\ GB}{2}$

respectively, that is—

$$Q_1 : Q_2 :: \frac{D B.\ A B}{2} : \frac{D B.\ G B}{2}$$

or

$$Q_1 : Q :: A B : G B$$

If the resistance of the conductor of the cable be small compared with the resistance of the battery, then since the quantities $R_1 + \rho$ and $R_2 + \rho$ are practically equal, we get

$$Q_1 : Q_2 :: R_1^2 : R_2^2$$

showing that

"*When a cable whose further end is to earth is charged by a battery whose resistance is large compared with the resistance of the conductor of the cable, the charge it will take will be* directly *proportional to the* square *of its length.*"

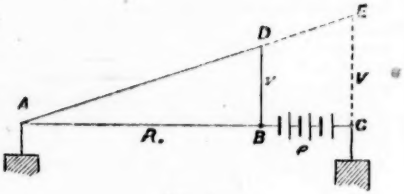

FIG. 1.

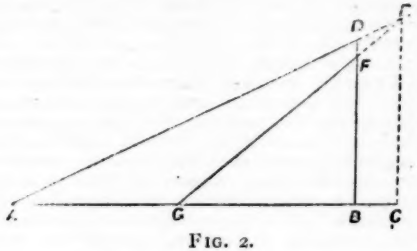

FIG. 2.

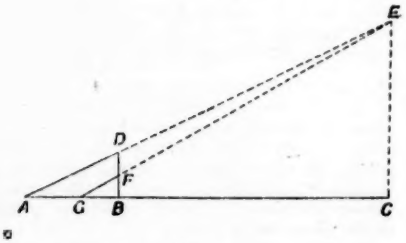

FIG. 3.

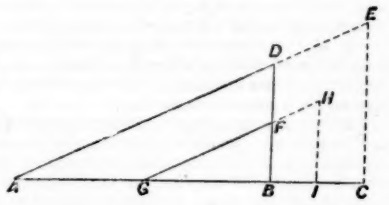

FIG. 4.

To prove the proposition geometrically, in the fig. let A B, G B, B C represent, as before, the resistances of the cables and battery.

Now the larger B C is compared with A B and G B, the nearer will A E and G E approach parallelism.

If we regard them as parallel, then the areas of the two triangles representing the charges in the two cables will be $\frac{D B.\ A B}{2}$ and $\frac{F B.\ G B}{2}$ respectively, that is—

$$Q_1 : Q_2 :: \frac{D B.\ A B}{2} : \frac{F B.\ G B}{2}$$

But when A E becomes parallel to G E, A D becomes parallel to G F, and the triangles A B D and G B F become similar; therefore—

$$F B : G B :: D B : A B$$

therefore—

$$F B = \frac{G B.\ D B}{A B}$$

therefore—

$$Q_1 : Q_2 :: \frac{D B.\ A B}{2} : \frac{D B\ (G B)^2}{2\ A B}$$

or

$$Q_1 : Q_2 :: (A B)^2 : (G B)^2$$

Let A B and G B be two cables, with currents of equal strengths flowing through them.

Now, in order that this may be so, since strength of current varies directly as potential and inversely as resistance, the potential D B must be to the potential F B as A B is to G B. When this is the case the triangles A B D and G B F are similar, and, consequently, as we have before proved, the charge taken by the two cables must be proportionate to the square of their length, showing that

"*When two or more cables whose further ends are to earth are charged so that the strengths of the currents flowing through their conductors are the same, the charge they will take will be* directly *proportiona to the* square *of their lengths.*"

If we call the charge which the cable will take when the end is insulated Q_3 then

$$Q_3 = V R_1$$

therefore

$$Q_1 : Q_3 :: \frac{V R_1^2}{2 (R_1 + \rho)} : V R_1$$

or

$$Q_1 : Q_3 :: R_1 : 2 (R_1 + \rho)$$

It will appear from this proportion that a cable charged by a battery of low resistance will take twice as much charge when the end is insulated as when it is to earth. This is also at once seen by a glance at the first fig.

THE LOAN COLLECTION OF SCIENTIFIC APPARATUS.

III.

TURNING our attention to printing or recording Telegraphs, we find here a large variety exhibited. The year 1837, which appears to have been the great year of Telegraphy, saw Morse's first production; but it was not until the year 1844 that the first Morse printing telegraphic line was erected and working in the United States. This was between Washington and Baltimore.

In the earliest form of the Morse a pen or style was used, and the sending apparatus was *automatic*, the letters being cast in a certain form which transmitted the necessary combinations of dots and dashes. Unfortunately, the present Exhibition is entirely unrepresented by the United States, and we can only suppose that the Philadelphia Exhibition, occurring at the same time, has deprived us of the view of many of the early telegraphic apparatus from the States.

One of the most important improvements in printing telegraphs was the chemical printing telegraph of Alexander Bain, which was patented in December, 1846. The receipt of signals was on paper chemically prepared with a solution of ferro-cyanide of potassium. A current passing through an iron style resting on the paper produced decomposition, and a blue mark was left, corresponding in length to the duration of the current.

At No. 1552 is exhibited the original "Bain's Chemical Telegraph. (Incomplete.) First form of recording instrument used in England, 1846." It is thus described in the catalogue:—"The chemically-prepared paper is wrapped round the cylinder. An iron style presses on the paper, and writes dots and dashes in a spiral line as the cylinder moves endwise while revolving. The signals are formed manually by pressing a key, or automatically by a spring, making contact through perforations previously punched in a paper ribbon."

In connection with his printing telegraph, Alexander Bain has the undoubted credit of the important principle of making up messages on paper perforated with the necessary signs. It is strange to think that now in 1876, the most approved form of telegraph, by reason of speed in working, is that of the punched paper, transmitting signals automatically, which are received on chemically-prepared paper.

Whilst in America the Morse was used with its derivate the "Sounder," in England the "Bain" was superseded about 1853 by the "Morse Embosser," which again, in its turn, gave way to the Ink-writer. In the Embosser the dots and dashes of the Morse alphabet are made by a rounded steel point, fixed at one end of a lever; the other end being furnished with an armature, and attracted by an electro-magnet, worked by a relay and local battery. At the present time many of the old Embossers are being converted into Sounders.

At 1533 are exhibited various forms of old ink-writers: whilst further on may be observed many of the forms now used, which, as regards efficiency and workmanship, contrast favourably with the older forms.

For purposes of signalling and transmitting signals, various forms of keys and relays are shown: amongst the former being many arrangements for correct spacing and for discharging the line wire. Amongst the relays are forms of the earliest patterns used; most notably is one of Siemens of 1851, the oldest form of polarised relay without a steel magnet; the magnetic induction of the core and keeper is effected by a branch current of the local battery.

At 1555 to 1557, will be noticed Wheatstone's automatic telegraph; the *perforator*, for punching the paper; the *transmitter*, for transmitting automatically the signals punched on the paper ribbon; and the *receiver*, for reading the signals, this is a very sensitive, direct ink-writer.

At 1567 the Postmaster-General exhibits a "Duplex Translator," for relaying the signals on long circuits worked on the duplex system; the apparatus really consisting of two sets of duplex instruments, which are combined for the purpose.

At 1675 is exhibited an instrument, the invention of Elic Wartmann, "for sending simultaneously in opposite directions telegraphic despatches between two stations with one single wire in the line."

At 1628 may be seen Frichsen and Siemens' "Relays, with suspended magnets, and double coils for conversation, 1854."

With regard to the recent introduction of duplex telegraphy, it is interesting to turn back to some excellent descriptions of the early form of instruments patented and introduced since 1854, which appeared in a well-known work on Telegraphy; but which, from peculiar circumstances, although successful, were found impracticable over many lines. The author concludes his description with these remarks:—"Both these systems of telegraphing in opposite directions, and of telegraphing in the same direction more than one message at a time, must be looked upon as little more than *feats of intellectual gymnastics*—very beautiful in their way, but useless in apractical point of view."

The rapid re-introduction of duplex and quadruplex telegraphy during the last few years has created a great revolution, and furnishes at once a ready reply to the above remarks. The invention of Mr. Stearns, of the United States, the speedy introduction of the "duplex" there, and its rapid transfer to this and other countries, are now well known. The invention is a great practical success, involving large economy, and it is now employed in this country to a considerable extent, as may be judged when we state that about 18,000 miles of wire are worked on this principle.

There are many of these instruments to which we have referred that can only be appreciated as specimens of workmanship; for, as the connections are out of sight and no definite descriptions given, it is impossible to understand them thoroughly, especially as you are politely requested "Not to touch." In such cases it is desirable, where the connection of wires are invisible, and cannot be followed, that, failing a verbal or written description, the instrument should be accompanied by a diagram explaining the connections, so that the inquiring mind may have the satisfaction of understanding the working of a "duplex translator," or any other instrument.

VOLTAIC ELECTRICITY.

BY PROFESSOR TYNDALL, D.C.L., LL.D., F.R.S.

LECTURE IV.

(Continued from page 188.)

TAKE a wide coil of covered copper wire, just as it comes from the makers, and, grasping it firmly in the hand, one side of the coil will be compressed and the other side of the set of rings will hang loosely away from each other. Now, send a voltaic current through the coil of wire, and the rings will be seen to be drawn forcibly together. That this motion is due to the mutual attraction of the coils is obvious.

When the end of a poker or any other rod of iron is inserted in this coil whilst it is unconnected with the battery, the poker has no attractive force for small pieces of iron; but, on sending a voltaic current through the wire, a parcel of tin tacks is immediately gathered up by the poker. In this case the space between the wire conveying the current and the poker which is rendered magnetic is very great. What is taking place in that space is a question which has exercised the minds of the most profound thinkers and most skilful experimenters in physical science, but has as yet received no satisfactory answer.

The poker is rendered magnetic, and has therefore a north and south end. That end of the poker will be north which is to the left of the current flowing from the positive to the negative side of the battery; that is to say, along the wire from the platinum to the zinc. The polarity of a spiral through which a current is flowing can be predicted in the same way. The left hand side of each of the coils of the spiral will be north, the right hand south, and the cumulative effect of the whole will be manifested at the two ends. This explains the mutual attraction of the coils of such a spiral, since north and south poles attract each other.

The polarity of a spiral through which a current is passing is beautifully shown by De la Rive's floating battery. A plate of zinc (an inch or two square) is placed between the folds of a bent plate of copper, and separated from it by bits of cork or wood. A piece of copper wire, covered with silk, is soldered to the copper plate, and, after being twisted into about twenty concentric coils, is fixed by its other extremity to the zinc plate. The whole apparatus is then placed in a shallow wooden cup, filled up with sulphuric acid in such a manner that the zinc and copper are submerged, and the whole floated on water; or it may be attached to a large bung in such a way that the coil is above the cork, and the metals beneath it, and then floated in a vessel containing diluted sulphuric acid. After a few oscillations the spiral will set itself along the magnetic meridian, each coil of wire crossing the meridian and presenting its left side (proceeding from copper to zinc) to the north. On presenting a magnet to the spiral, it is attracted and repelled by opposite ends, as if it were itself a magnet.

Seeing, then, that magnets are made by the passage of an electric current round bars of iron and steel, and that the north pole of such magnets is always to the left of the current; and that the electric currents themselves show all the phenomena and comply with all the laws of magnetism; Ampère went a step further, and assumed that round the constituent molecules of magnets there are perpetually circulating currents, and that the attraction and repulsion exerted between magnets and electric currents are due alone to the mutual action between these currents. The whole class of electro-magnetic rotations, magnetic properties of coils, the inductive action of magnets on neighbouring conductors, and even the magnetic properties of the earth itself, are thus reduced to one sole hypothesis and fact which fall in well with all the experiments on the subject—Ampère's great hypothesis being, that a magnet consists of a series of circulating electric currents; and his fact, that electric currents attract and repel each other.

Currents running in the same direction attract each other; currents running in opposite directions repel each other. A rectangle of wire with its ends in cups of mercury, so that a current can be sent through it and yet leave it free to move, is attracted by a wire brought near it when the currents agree in direction, but is repelled if the direction of the current in the wire is reversed, either at the battery or by simply reversing the wire itself.

The consideration of these phenomena will render easy the comprehension of Faraday's great experiments on magnetic rotation. The magnet is supposed to have electric currents circulating round it. The direction of these currents is easy to predict. The currents must so flow as to have the north end to their left, and will, consequently, if the magnet be placed vertically with its north end upwards, from left to right.

Supposing now a wire conveying an electric current is made to run parallel with the magnet, it will tend to travel round the pole in the direction of the currents round the magnet; and if the current in the wire is reversed it will rotate in the opposite direction.

(Faraday's original apparatus was made use of in showing these experiments). Reciprocity of action was shown by the rotation of magnets round a central current, and also the crucial experiment devised by Faraday, whereby a magnet carrying a voltaic current through itself was made to rotate on its own axis by virtue of the interaction of the two currents.

If a wire conveying a current is submitted to the action of both magnetic poles instead of one only, it can be made to vibrate if so suspended that one end dips in a small cup of mercury between the poles. According to the direction of the current it will be either attracted or repelled, and will then leave the mercury, but as it breaks contact by so doing, gravity comes into play, and it falls back into the cups, to be again ejected on restoration of the current.

Barlow's wheel is an extension of this experiment. The electric current is made to pass through a copper spur wheel from its axis to its points, which dip successively in a cup of mercury placed between the poles of a magnet. As soon as the current descends the radius wheel, the portion dipping in the mercury is thrown out, as was the case with the vibrating wire, but by this action a

second spoke is brought forward and the current restored; this is, in turn thrown forward, and thus a continuous rotation of the wheel is established. By substituting an entire copper disc for the radial one, the motion is rendered more even. The explanation remains the same: the current takes the nearest direction between the axis and the cup of mercury, and is thus constantly either attracted or driven away, and carries the wheel with it, before it has time to loose its grasp on the metal.

When the end of a cylinder of iron is introduced into an electro-magnetic helix, on completing the circuit a force of suction is exerted upon it, tending to draw it into the helix. Page turned this force to account in the construction of an electro-magnetic engine. (A machine on this principle was built up for the present course of lectures, and worked with great display of force, considering the small amount of battery power employed.)

Hollow iron cylinders, which pass freely into the helices, are employed for this experiment. The end only of the hollow cylinder being introduced, when the circuit is completed the cylinder is suddenly and strongly sucked in.

Others have turned to account mechanically the attraction exerted by electro-magnetic cores on bars of iron. The distinguished electro-mechanician Froment produced rotatory motion in the following manner:—A series of electro-magnets are so ranged that their poles lie facing each other along the circumference of a circle; and a series of transverse bars of iron are so connected together as to be able to approach the poles in succession and rotate as a system. When the circuit is thus established, these bars are attracted, motion being thus imparted to the system. The bars, on arriving at the poles which attract them, suddenly cease to be attracted; the magnetism being temporarily suspended to allow each bar to pass forward, with the velocity impressed upon it, to the next pair of attracting poles. On reaching these, the magnetism is temporarily suspended. Thus the bars are never pulled back; and in this way a continuous motion of rotation is maintained.

THE LATE HENRY MOXON.

THE remains of this promising telegraph engineer were interred in the Harpurhey Cemetery, on the 23rd ult., amidst very extensive tokens of respect from friends and colleagues. He died of inflammation of the lungs, in his thirty-ninth year. He was originally in the service of the Magnetic Telegraph Company, and about 1861 he succeeded Mr. Ramsbottom as superintendent of the telegraph department of the Lancashire and Yorkshire Railway Company—which appointment he held until his death. He had recently acquired considerable reputation through the skill and ability with which he had conducted the case of his employers against the Post-office. He was an earnest student of telegraphy in all its branches, and devoted considerable perseverance to the improvement of the various applications of electricity to railway purposes. He introduced a capital self-acting signal, by means of which the arrival of each train is announced by ringing a bell. He invented also a "Single-needle Morse printing apparatus," which recorded what is known as Steinheil's alphabet. He was a member of the Society of Telegraph Engineers.

His loss will be severely felt; for he combined wonderful energy, both of mind and body, with high mental qualities. He introduced upon his railway a block system which is distinguished by much care in the preparation of its rules and regulations, and by an entire absence of those conventions and traditions which mark the systems in use on contiguous railways. He was alive to every improvement introduced elsewhere, and ready to meet with skill and ingenuity every defect that developed itself. The safety of our railway system is due to the patient and untold labours of such able and practical workers as Henry Moxon. He leaves a wife and three children.

Notes.

ON the evening of Saturday, July 1st, Professor Tyndall lectured to a crowded audience in the theatre of South Kensington Museum on "Faraday's Apparatus"; the lecture forming one of a series of free evening lectures on the instruments of the Special Loan Collection of Scientific Apparatus. It was a popular exposition of the progress of Faraday's discoveries in induced electricity, and most of the experiments were performed with the original apparatus which Faraday used.

A new apparatus for telegraph signalling has lately been brought into notice. It is the invention of a Spanish gentleman, and its object is to enable any number of stations, houses, fire-offices, police stations, &c., to communicate with a central station by the same wire without interfering with one another—a thing which cannot be done by any present system of telegraphy. The essence of the system may be said to consist in the use of two independent wires, the earth being in each case used to complete the circuit. Of these, one wire serves to carry the message, the other to set the instruments and connections in a condition to carry it (they may be called the "sending" and the "starting" wires respectively). The operator, by one and the same action, sends a message along the starting wire which cut off all communication between the starting wire and the receiving instrument, throws the receiving instrument into connection with the sending wire, and transmits his message. Nobody can send a message along the sending wire till he has sent one along the starting wire, since it is by the current flowing along the starting wire that his sending instru-

ment is put in action. Nobody can send the requisite starting message while anyone else is telegraphing; for, during the process, the starting wire is disconnected from the receiving instrument. Not only this; but if, while one person is telegraphing, another attempts to do the same, this second person, though he does not actually send his message, yet puts his connections in such a position, that as soon as the instrument at the central station has received the previous message and regained its normal position, the circuit with his instrument will be completed and his message sent. [A more detailed account of this invention will probably appear in our columns shortly.]

The traffic receipts of the West-coast of America Telegraph Company for the four weeks ending April 8 were at 40d. per dollar, £2,499.

The report of the Eastern Telegraph Company for the half-year ended 31st March last shows a balance of £99,136, which with £22,986 brought forward, leaves available for distribution £122,122. The preferential and debenture interest absorbed £7,519, the interim dividend already paid £46,212, and it is now proposed to pay a further dividend of 2s. 6d. per share (making 5 per cent. for the year), and carry £22,179 to the reserve fund, which is thus raised to £185,765.

The traffic receipts of the Western and Brazilian Telegraph Company Limited for the month of June were £9,623 against £9,088 for the corresponding month of last year. It is stated (July 3) that the interruption between Bahia and Pernambuco does not interfere with the traffic to the Brazils and South America generally, as messages are sent over land lines between those places without extra charge and without delay. The repairing ship has left to restore communication. The cable was interrupted in shallow water.

The current number (5) of *Poggendorff's Annalen* contains a large proportion of papers on electric subjects. We subjoin the titles, and hope shortly to give abstracts of some or all of the papers:—"On Dielectric Polarisation," by M. Root; "On the Laws of Passage of Electricity through Gases," by M. Wiedemann; "On the Electro-motive Forces induced by Motion in an Unclosed Circuit," by M. Helmholtz: "A Controverting of Helmholtz's Elementary Potential Law by Electrodynamic Experiments with Closed Currents": "On some forms of Silver obtained Galvanically," by M. Kirmis; "On Galvanic Expansion," by M. Edlund; "On Irreciprocal Conduction of Electric Currents," by M. Christiani; "On the forms of Electric Sparks," by M. Peters.

The first annual report of the magnetic observations at the new observatory of Zi-ka-wei, in China, has lately reached Europe. An account of the results obtained—which are of considerable interest to those engaged in the study of terrestrial magnetism—is furnished by Father Perry to *Nature* (June 29).

The number of messages passing over the lines of the Cuba Submarine Telegraph Company Limited during the month of June was 2,759, estimated to produce £2,600, against 2,490 messages, producing £2,400, in the corresponding month of last year. The traffic receipts for the month of April, estimated at £2,700, realised £2,940. The half-yearly report of the same Company recommends a dividend at the rate of 7 per cent. The sum of £3,623 is placed the reserve fund, increasing it to £12,000, and £1,459 remains to be carried forward to the next account. The Report adds, that the Company's lines have continued in good working order, and that no interruption of importance has occurred on the lines of contiguous Companies.

The Directors of the Anglo-American Telegraph Company have resolved, after reserving £25,000 for the renewal fund, to declare an interim dividend, for the quarter ending June 30th, of 1¼ per cent. on the Consolidated Stock, and of 2½ per cent. on the Preferred Stock, both free of income-tax, payable on the 1st August, leaving a balance of £22,000 to be carried forward to next quarter's account.

The traffic receipts of the Great Northern Telegraph Company for the month of June amounted to 467,528 francs, as against 390,076 francs in the same month last year. The total traffic receipts from 1st January to 30th June were, this year, 2,239,387 francs; last year, 1,933,267 francs.

The traffic receipts of the Direct Spanish Telegraph Company for June were £541 0s. 11d., against £1,464 3s. 2d. in the corresponding period of last year.

The new joint for gutta-percha covered wires, devised by Mr. Willoughby Smith, is formed by removing the coatings from the two ends to be united, and joining the cleaned wires by what is technically known as the "bell-hanger's twist." No solder is necessary. The twist is then warmed slightly, and covered with a rough coating of insulating "compound," somewhat thicker than the original diameter of the wire. The joint, while warm, is placed in the lower half of a small wooden block, about three inches long and one

inch wide, fitted internally with a groove for the wire, widening in the middle into a niche, about an inch and a half in length, for the reception of the compound-covered joint. While the compound is yet warm, the upper half of the mould—in shape corresponding exactly with the lower one—is placed on the top, and by means of a clamp, screwed down until the two wooden surfaces are pressed firmly together. While in this position they are permanently fixed by half-a-dozen ordinary brass screws, and, the compound having hardened, the clamp is removed and the joint complete. The principal advantage claimed for the new joint is its simplicity, as it can be readily made by comparatively experienced hands in about ten minutes. The cost is reduced to a very low figure, and, by means of the wooden cover, all danger of leakage or separation of the wires through bending is obviated.

A Victorian paper (B.C.) gives an account of some strange freaks of atmospheric electricity, during a recent thunderstorm. A lady residing next to a girl's schoolroom, heard a great crash in the building, and mentioned the fact to some friends. On entering it was found that the green baize doors near the entrance had been torn from their hinges, that the black boards lay on the floor, and that the lid of every desk, of which there were 144, was open and thrown back. Several of the lids had been torn from their hinges, others were partially so; but without exception every desk stood open, and some were half filled with water as if a bucketful had been dashed into them. The back door, like the green baize door, had been torn from its hinges and lay prostrate. The lightning evidently entered by the front windows, which were opened, and passed out of the back windows, which were also opened. Its course after leaving the building could not be traced. Had the accident happened two hours earlier, a dreadful tragedy might have occurred.

The Atlantic and Pacific Telegraph Company are proceeding with the work of constructing the new lines from Cincinnati *viâ* Louisville and Memphis south to New Orleans. The construction will commence at Cincinnati and be pushed ahead as rapidly as possible.

The Franklin Telegraph Company (Boston, Mass.) have leased their lines to the Atlantic and Pacific Company for a term of 99 years.

Recently, at a meeting of the Philomathic Society of Paris, M. Cazin described some observations on the spectrum of the electric spark in air at high pressures. In nitrogen compressed up to 40 atmospheres two or three lines of nitrogen continue to appear on a luminous ground, with the principal lines of platinum. Repeating the experiment with air, he remarked, after passing 30 atmospheres, a new spectrum composed of dark lines with perfectly distinct borders, and at nearly equal intervals, to the number of 20, extending from the yellow to the violet. Their arrangement presents a sort of characteristic rhythm. These lines do not appear in nitrogen. The air which produces them is filled with intense rutilant vapours, so that it might be thought the case was that of an absorption spectrum of hyponitric acid. This was verified, on producing this spectrum with the Drummond light and a layer of rutilant vapours of 10 centimetres thickness.

In an underground telegraph system which is now in use at the Centennial Exhibition, connecting the Finance and Commissioners' Buildings, the naked copper wires are drawn through glass tubes, which are firmly held in position in the iron pipe by paraffine wax. For lateral connections, as well as convenience in laying, traps are used, into which the pipe is screwed, the wires passing over non-conducting bridges, thus allowing any wire to be taken out and replaced without interfering with the working of the others. The pipes are connected by a coupling which after being bolted together, is completely sealed; the traps being closed and sealed in like manner. By this system there is claimed to be no crossing of wires, no difficulty from atmospheric changes, no cutting of wires in cases of riot, no imperilling of life and property by the breaking down of poles and wires by snow storms or fires (causing interruption of telegraphic communication): but a perfectly reliable telegraphic connection under all circumstances.

At a recent meeting of the Massachussetts Instituto of Technology, Prof. William Robinson read a paper on his system of wireless electric railway signalling. In it a new principle is involved. The rail section may be one or several miles in length; at one end the battery is placed, one pole attached to each rail, while at the opposite end is the magnet, one electrode to each rail. Thus a constant metallic long-circuit is established through the rails and the magnet. When a train enters the section from either end, or from a siding, it short-circuits the current, because its wheels and axles are better conductors than the small wire of the magnet. The magnet, being thus demagnetised, releases its armature, throwing the signal to danger, where it remains while the train, or a car, is on the section. On double-track roads, no line wires are used.

Proceedings of Societies.

PHYSICAL SOCIETY—24TH JUNE, 1876.

Professor G. C. FOSTER, President, in the chair.

THE following candidates were elected members of the Society:—Prof. James Dewar, F.R.S.E., and the Hon. F. A. Rollo Russell.

PROF. GUTHRIE showed the action of Prof. Mach's apparatus for exhibiting to an audience the effect of lenses on a beam of light passed through them. It consists of a long rectangular box with glass sides, in which are several movable lenses. A parallel beam of light falls on a grating at one end of this box, and is thus split up into a number of small beams, which are rendered visible by filling the box with smoke. After passing through the first lens the rays fall on a movable white rod, which may be placed to indicate the focus. The light then falls on another lens partly covered with red and part with blue glass, in order to more precisely exhibit the paths of the rays.

BARON WRANGELL exhibited the apparatus employed by Petrochovsky in his magnetic experiments. These experiments had reference to (1) Normal magnetisation; (2) The measurement of the distance of the poles of a magnet from its ends, and (3) A thermo-electric apparatus. The determinations were very much simplified by employing a unipolar magnetic needle, formed by a bending a small bar magnet at right angles at about a quarter of its length from one end. The needle is then suspended by a fibre attached to the end of the short arm, and the longer arm is maintained horizontal by a brass counterpoise weight. It will be evident that as one pole is in the axis of rotation it cannot have any effect on the motion of the needle. By turning up each end in this manner the moment of the magnet may be ascertained without knowing the exact positions of the poles. If a magnetic needle be so placed that a bar magnet parallel to it has no effect in deflecting it from the meridian, and the bar be then struck with a hammer, the state of equilibrium will be disturbed, as is shown by the motion of the needle. This, however, is not the case with a piece of soft iron round which an electric current is passing. The apparatus employed in the experiments on "normal magnetisation" consisted of an arrangement for passing a current round rods of soft iron of varying lengths, so constructed that any number of the surrounding coils can be removed in the manner of an ordinary rheostat. After the current has been passed round the bar it is moved until its residual magnetism has no effect in deflecting a delicate unipolar needle from the meridian. The current is then passed round it, and the coils are adjusted, until the magnetised bar has still no effect on the needle. The effect of the coils themselves is eliminated by means of a subsidiary coil. When the current is thus adjusted the bar is said to be "normally" magnetised, and M. Petrochovsky has ascertained that this condition is satisfied when the length of the coil is 0·8 times that of the bars, and this is independent of the strength of current. This then is the only case in which the position of the poles is the same as when the bar is charged with residual magnetism. For the determination of the positions of the poles of a bar magnet a somewhat complicated apparatus was employed. A larger unipolar magnet about eight inches in length, provided with a bifilar suspension, was enclosed in a glass box. A fine silver wire was stretched parallel to the axis of the needle between two projections on it, and it also carried a fine index at the horizontal end. The wire is focussed in a telescope which can be made to travel along rails parallel to the magnet, and the index at the end can be observed by another telescope. A small magnet at right angles to the large magnet can be moved with the first telescope, and the point at which its effect in deflecting the unipolar is the greatest, is ascertained by varying its position parallel to itself along a graduated scale, and then observing the space through which a subsidiary magnet must be moved in order to restore the unipolar to its initial position, as observed in the second telescope. When this point is reached it must be exactly opposite the poles of the large magnet. It was thus found that the poles are at a distance of one-tenth of the length of the magnet from its ends. To determine the position of the poles of a horse-shoe magnet a delicate magnetic needle is placed below a fine wire in the meridian, and a horse-shoe magnet is brought so that its two ends are immediately below the wire and near the needle. In the case of an electro-magnet the point at which its effect is greatest is found to vary when the coils are moved towards the ends, and is nearest to the ends when the coils project slightly beyond them. The third series of researches referred to was on the influence of an electric current on the thermo-electric action of soft iron. A number of strips of iron are connected by means of copper studs, and when currents are passed round the alternate strips it is found that the system acts as an ordinary thermopile. This question is, however, still under investigation.

In reply to a question of the President, Baron WRANGELL stated that the effect of increasing the number of coils in the horse-shoe magnet on the position of the poles is also still under investigation.

PROF. BARRETT then made a brief communication on the magnetisation of cobalt and nickel. He has recently made some experiments on these metals with a view to ascertain whether they undergo any elongation or contraction similar to to that experienced by iron during magnetisation. From his first experiments he concluded that cobalt elongates slightly, but that there is no effect on nickel, but this latter result may have been due to the fact that the metal was not absolutely pure. He has, however, obtained through Mr. Gore a fine bar of pure nickel about two feet in length, and now finds that it contracts, and that the amount of this contraction is about the same as that of a like iron bar when similarly treated.

PROF. GUTHRIE then described some experiments on the freezing of aqueous solutions of colloid substances, which he has been studying in connection with his recent investigations on cryohydrates, &c. If a solution of sugar be gradually cooled, the temperature at which ice separates

out is always below 0°C, and the extent below increases with the amount of sugar in solution. But he finds that in a solution of gum having exactly the same chemical formula, the ice always separates at 0°C whatever be the amount of gum present. Thus while every crystalline substance forms a freezing mixture when mixed with ice or snow, colloids are incapable of doing so. The gum and the water do not recognise each other; and similar results were obtained in the case of gelatine and albumen. These facts are strictly in accordance with the results of Prof. Graham's classical researches. It almost follows that when heated similar effects are observed, and Prof. Guthrie has found that solutions of gum in varying proportions always boil at 100°C.

MR. W. CHANDLER ROBERTS said that this important discovery was one that his late distinguished master would have welcomed, and he expressed a hope that Dr. Guthrie would continue his experiments with the series of colloids actually prepared by Graham.

PROF. GUTHRIE then showed the experiment by which Dr. Kerr has recently proved that glass, resin, and certain other substances exhibit a depolarising effect when under the influence of a powerful electrical tension. With the help of Mr. Lodge, Dr. Guthrie has succeeded in repeating these exceedingly delicate observations, but the effect is very slight and ill-suited for the lecture-room. A beam of polarised light traverses a thick plate of glass in which two holes have been drilled nearly meeting in the centre, and two wires are fixed in these and connected with the terminals of a powerful coil. The light, after passing through the analyser falls on the screen. If now the analyser be so turned that the illumination is least before the current is turned on, the brightness of the field will be seen to increase as soon as the circuit is closed, and this brightness will increase up to a certain limit. The effect is greatest when the light is polarised at an angle of 45° to the line joining the terminals.

The PRESIDENT then adjourned the meetings of the Society until November.

Electrical Science in Foreign Journals.

COMPTES RENDUS OF PARIS ACADEMY. No. 25: 19TH JUNE, 1876.

Influence of Temperature on Magnetism. By M. GAUGAIN.

THE following facts, chiefly, were noted in a previous paper: When a steel bar in contact with one pole of a magnet is gradually heated till it takes a blue colour, its magnetism (as measured at the middle by the demagnetisation-current) increases, reaches a maximum, and then decreases. This is shown from one experiment by the following series of numbers (representing magnetism): 44·51, 55·2, 52, 52·8, 52·1, 50, 48·5, 48, 48. If the bar be let cool in contact with the magnet, the whole magnetism increases with the cooling, and when the bar has come down to ordinary temperature, the magnetism is much higher than before heating. Thus, before heating, in one case it was 41·6; at the end, 63·2. The whole magnetism of the cooled bar is greater the more strongly the bar has been heated, at least up to the temperature giving a blue colour. When the bar is entirely cooled, a separation of magnet and bar for only a few seconds suffices to dissipate part of the increase of magnetism acquired through heating; still, the whole magnetism remains greater than before heating. These former experiments were on Sheffield steel bars. Allevard steel, to which the present note refers, behaves differently. In continuous heating, its magnetism showed no retrogression even at the blue tint (about 300°). Again, M. Gaugain tried the effects of repeated heatings and coolings. The two magnetisms, corresponding to the lower and higher temperatures respectively, gradually increase; but at length, with sufficient repetition, they become invariable. The bar, then, undergoes two sorts of modifications; one *permanent*, resulting in an increase of magnetisation corresponding to any given temperature; the other *transient*, having for effect the diminution or increase of the magnetisation, according as the temperature rises or falls. M. Gaugain determined the extent of these modifications comparatively for the Sheffield and Allevard steels. Both undergo nearly the same permanent modification, when submitted to the same alterations of temperature, but the transient modification is much greater in Sheffield steel than in Allevard. "According to the theoretic views I have ventured to formulate, the permanent modification will represent a veritable increase of magnetisation; I suppose that the coercive force is diminished through the variations of temperature, and that, consequently, the molecules come gradually nearer by magnetic orientation; the transient modification probably arises from the fact that the inductive action excited on a bobbin diminishes when the temperature increases, even when we suppose that the magnetisation, that is, the orientation of the molecules, does not vary."

Extension of the Principle of Carnot to the theory of Electric Phenomena. General differential equations of Equilibrium and of Motion of any reversible electric system.—Extract from Memoir by M. LIPPMANN.

Differential Electro-actinometer. By M. EGOROFF.

THIS is for determining the co-efficients of absorption of ultraviolet rays by different media. It consists of two of Becquerel's actinometers placed one above another, and so arranged that the current of one is neutralised by that of the other. A very sensitive mirror galvanometer is inserted in the circuit. Each actinometer consists of a parallelopipedal glass-case with two opposite plates of hardened caoutchouc, each having two slits in which are fixed silver plates. The two actinometers are in a common box, the two surfaces of which, that correspond to the quartz plates of the actinometers, are movable in slides. One of the movable plates has two superposed slits of variable width, corresponding to the two actinometers. As the sensitiveness of the plates of iodised silver varies with the time of exposure, the slits are made movable over the whole length of the plates. The method of observation is this: Fix on an aperture for the two slits, regulating four plates of the actinometers to the same sensi-

bility, then place the absorbing substance to be studied, between the light and the slit corresponding to one of the actinometers—*e.g.*, the lower, and note the deflections of the galvanometer, (1) When only one of the actinometers is open; (2) when the two act together. The author further describes some preliminary studies of the course of the phenomenon. It appeared that there was exact proportionality between the intensity of the light and that of the current; and the apparatus may be considered as a very delicate photometer.

No. 26: 26TH JUNE.

New Experimental Considerations on Mr. Crookes's Radiometer. By M. LEDIEU.

IN Germany (he states) an explanation of the instrument is given, based on electricity. In a radiometer with vanes having both faces polished, and with a continuous electric spark traversing one of the hemispheres of the vessel, the tourniquet turns rapidly in the direction opposite to that of the spark. It has been thought that in the ordinary action of the instrument, thermo-electric currents are generated in the vanes, turning under the action of the earth-current. M. Ledieu thinks the construction of the vanes against this hypothesis, and he undertakes to explain the new phenomenon in harmony with his view, that the motion is due to mechanical action of vibrations of ether.

JOURNAL DE PHYSIQUE, MAY, 1876.

On a Rapid Method of Determining the interior Resistance of a Battery. By M. MOUTON.

INTRODUCE into a circuit a rheostat R and a galvanometer G; the latter gives a deflection δ. Then throw a bridge across the circuit of resistance S; between the battery and instruments, the deflection diminishes, but it can be brought back to its former value δ by diminishing the wire of the rheostat R. Let G be the resistance of the galvanometer, b that of the wire of the rheostat in the first experiment; then making i the intensity of the current corresponding to deflection δ; E the electro-motive force of the battery, and R its resistance increased by the wires meeting at the bridge, $i = \frac{E}{R + b + G}$ In the second experiment the rheostat is reduced to b', and if, by the equations of Kirchhoff, or simply by Ohm's method of reduced lengths, we calculate the intensity of the current passing in the galvanometer, and still equal to i, we find

$$i = \frac{E\,s}{R\,(s + b' + G) + s\,(b' + G)}$$

whence, equating and reducing, $R = s\,\frac{b - b'}{b' + G}$

a formula which requires the knowledge of the resistance G in units of the rheostat. With an ordinary galvanometer and Pouillet rheocord (*e.g.*) at its maximum resistance, to obtain a deflection of 30 or 40 degrees, it will not be necessary to send the whole current, but merely a shunt from a length not exceeding three or four centimetres of a copper wire one metre in diameter. The resistance G, inferior to three or four centimetres of such wire, becomes negligeable in comparison with b' in all usual cases, and the formula is reduced to $R = s\,\frac{b - b'}{b'}$ But the factor $\frac{b - b'}{b'}$ being merely formed of homogeneous terms, the numbers b and b' may be simply the lengths of wire shown by the rheostat, and the resistance R is thus expressed in the same units of resistance as those which express s.

Effects of Lightning on Trees and Ligneous Plants. By M. COLLADON. Reserved.

JUNE.

On the Penetration of Charges in Insulating Bodies, Fixed and in Motion. By M. RIGHI.

WITH certain precautions (specified) it may be shown that an insulating plate, charged by friction on one of its faces, acquires on the other a charge of the contrary sign when the latter touches a conductor, especially an uninsulated one, or when it is touched by the hot gases of a flame or of burning charcoal, or by moist air, or is near a conductor armed with points. In the case of moist air, the induced charge forms spontaneously by degrees. Its limiting value in every case is such that its action on the conductor (or on the neighbouring points of the gas) destroys the opposite action of the rubbed face. If between a rectangular ebonite plate A, charged negatively, and an uninsulated metallic comb parallel to the two small sides of the rectangle, there is a second plate B of the same size and parallel to A, B acquires a positive charge, certainly less in absolute quantity than that of the inductor; but as it occupies a small surface on B, its superficial density may be greater. If the plate B be then moved so as to glide all over the comb, it may acquire a positive charge greater than the negative of the plate A. If the two plates be enclosed together in an insulated conductor, this will appear positive. The induced charge of density greater than the inductor may also form on one or the other of the two faces of the rubbed plate itself. It is sufficient to rub strongly a rectangular plate, and then to make it glide over the comb, to find it afterwards showing the contrary sign. Thus, if between the rubbers and the combs of a friction machine, a comb communicating with the ground be brought near the glass plate, the glass which comes positive goes away negative and the conductors of the machines are charged negatively. These and other experiments described throw light on many phenomena of induction-machines.

To Correspondents.

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